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(71) Applicant(s)
Royal Ordnance Plc
(Incorporated in the United Kingdom)
Griffin House, 5 The Strand, LONDON, WC2N 5BB, United Kingdom

(72) Inventor(s)
David Gerald Davies
Ronald Benjamin Holt

(74) Agent and/or Address for Service
Royal Ordnance Plc
PO Box 87, IPR & Contracts Policy Dept,
Lancaster House, Farnborough Aerospace Centre,
FARNBOROUGH, Hants, GU14 6YU, United Kingdom

(54) Abstract Title
A gun propellant composition

(57) A gun propellant composition comprises the following components in the stated relative proportions by weight, the sum of the relative proportions adding to 100:

Component A:	a mixture of nitrocellulose and nitroglycerine 30 to 40 parts
Component B:	RDX (cyclo-1,3,5-trimethylene --2,4,6-trinitramine) 50 to 60 parts
Component C:	carbamite (diethyldiphenyl urea) 1 to 10 parts.

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At least on drawing originally filed was informal and the print reproduced here is taken from a lat r filed formal copy.

Fig. 1

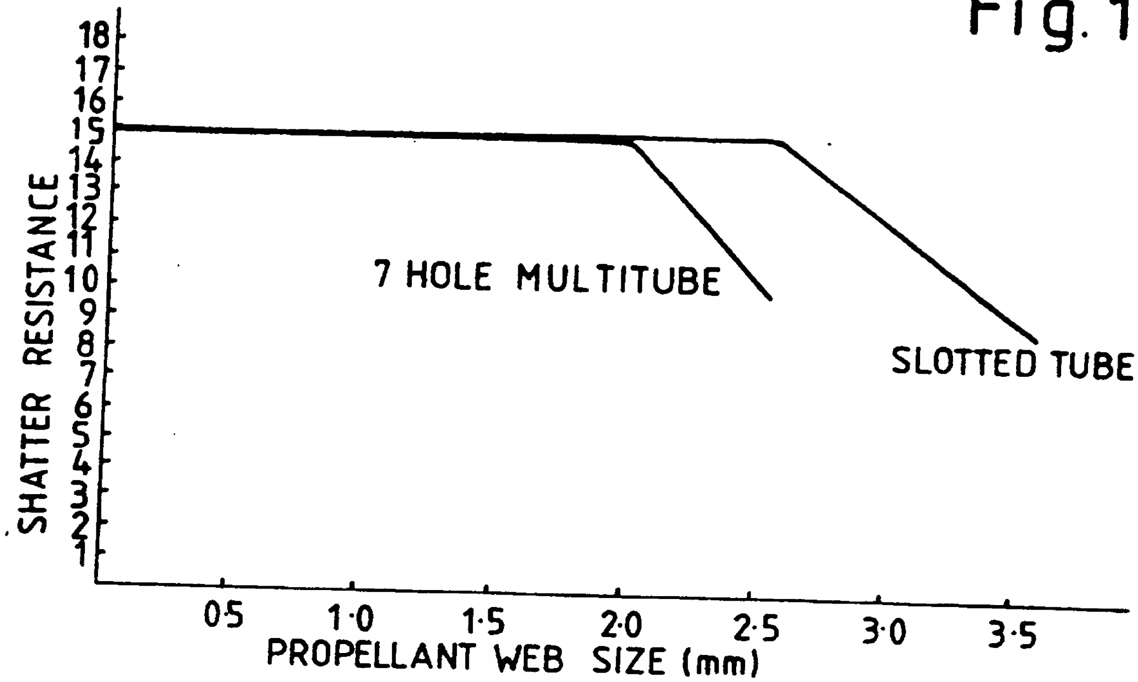
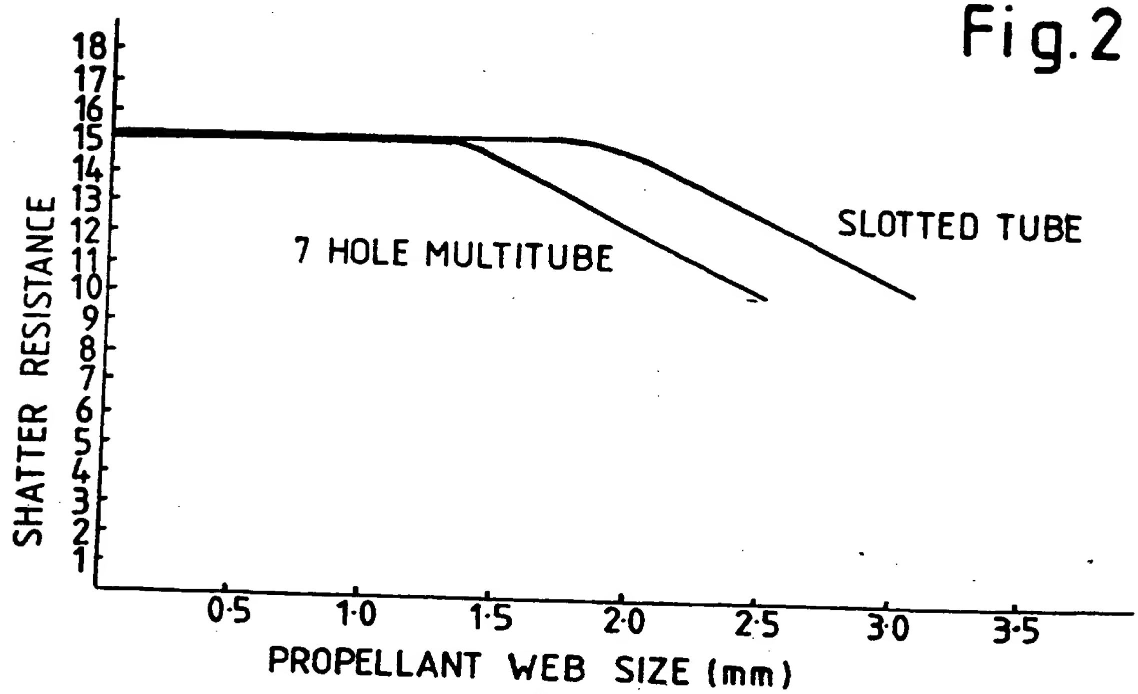

SHATTER RESISTANCE
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
7 HOLE MULTITUBE
SLOTTED TUBE
0·5
1·0
1·5
2·0
2·5
3·0
3·5
PROPELLANT WEB SIZE (mm)

Fig. 2


SHATTER RESISTANCE
18
17
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7 HOLE MULTITUBE
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3·0
3·5
PROPELLANT WEB SIZE (mm)

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GUN PROPELLANTS

The present invention relates to gun propellants particularly for use with high kinetic energy projectiles and compositions suitable therefor.

Propellants which are used to fire projectiles from a gun are formed according to the kind of gun and projectile involved. In a number of applications, such as the firing of long rod, fin stabilised projectiles from a tank gun the propellant is designed to produce a high kinetic energy firing.

A conventional propellant composition previously used in high kinetic energy applications is one of the so called "triple base" kind comprising the following constituents by weight: 20.8% nitrocellulose; 20.6% nitroglycerine; 55% picrite; together with 3.6% of the minor constituent carbamite. This composition will hereinafter be referred to as Composition A.

Such a composition shows force constant, a conventional measure of its energy 1 vel, of 1060 kiloJoules per kilogramme.

The new generation of tank guns are required to produce higher projectile velocities than those previously achieved in order to give greater armour penetration. Since the gun chamber volume is fixed and the propellant density within the chamber already approaches the maximum, it is not possible to increase the charge weight and it is therefore necessary to employ a propellant of higher force constant i.e. higher than that of Composition A. Preferably, the force constant is at least 1200 kJ per kg.

The simplest approach to increasing the propellant force constant of nitroglycerine based (e.g. triple base) compositions such as Composition A is to increase the nitroglycerine content. However such propellant compositions show disadvantages as follows and these become more serious as the nitroglycerine content is increased. Firstly, granules of such propellant materials have been found to show a high tendency to shatter on firing. The degree of shattering varies from one firing to another giving non-uniform projectile ballistics. Secondly, storage at low temperature (e.g. below 15^{o}C) has been found to produce exudation of nitroglycerine as a separate phase on the surface of the solid propellant material. As nitroglycerine in this form is a highly explosive material which may be initiated by a very small perturbation energy storage of the propellant is very hazardous. Migration of nitroglycerine into the combustible cartridge case (where used) may also occur leading to reduced gun and charge lifetime. Furthermore an increase in nitroglycerine content produces an increase in flame temperature which can become unacceptably high thereby causing severe barrel erosion.

According to the present invention a gun propellant composition comprises the following components in the stated relative proportions by weight, the sum of the relative proportions adding to 100:

Component A:	a mixture of nitrocellulose and nitroglycerine	30 to 40
Component B:	RDX (cyclo-1,3,5-trimethylene -2,4,6-trinitramine)	50 to 60
Component C:	carbamite (diethyldiphenyl urea)	1 to 10

Preferably, nitrocellulose (NC) and nitroglycerine (NG) are present in the said composition in the relative proportions of A parts by weight of NC and B parts by weight of NG where A is in the inclusive range 40 to 60 and B is in the inclusive range 60 to 40. Desirably, the ratio of A:B is in the inclusive range 50 to 55:50.

Preferably, the weight percentage content of nitrogen in the nitrocellulose is in the range 12 to 14 per cent. Preferably, the relative percentage by weight of RDX present in the said composition is from 53% to 57%, desirably 55%.

Preferably, the relative percentage by weight of carbamite present in the said composition is from 3% to 5%.

The above composition may be mixed together with further minor additive components contributing a total percentage by weight of 20 per cent by weight of the overall mixture. For example, such minor additive components may be selected from alternative energetic crystalline fillers, flash suppressants and energetic or non-energetic plasticisers.

For example, the alternative crystalline filler picrite (nitroguanidine) may comprise 1 to 5% by weight of the overall mixture.

A non-energetic plasticiser, for example a plasticiser which is a di-alkyl phthalate, e.g. dibutyl phthalate, may comprise from 3 to 6 percent by weight of the overall mixture.

A potassium or sodium salt, e.g. potassium sulphate or bicarbonate, may be present as flash suppressant to an extent of 0.5 to 2 percent by weight of the overall mixture.

Nitramines such as RDX are known highly energetic crystalline fillers and their use as a constituent in propellant compositions has, like that of many other crystalline fillers, previously been suggested. However, the nitramine content in the composition has to be carefully selected together with the other composition components and their relative proportions to give a combination of beneficial properties. The compositions according to the present invention have been specially selected to give such a beneficial combination of properties. Such compositions show in addition to a high propellant force an acceptably low flame temperature, thereby avoiding the erosion problems mentioned above, as well as a good processibility by known solvent based processing techniques and an excellent shatter resistance. Furthermore, such compositions do not show the problem of nitroglycerine exudation.

Compositions according to the present invention may be processed into propellant products by techniques which are generally know per se. For example, nitrocellulose and nitroglycerine in the form of dry paste are loaded into an incorporator (blender) in the presence of a suitable solvent, e.g. ethanol, acetone, ethyl acetate, diethyl ether or mixtures thereof. Optional plasticisers are added to further solvent and then poured into the incorporator. RDX together with carbamite and any other optional solid additives are added to the mixture in the incorporator. Further solvent is added to the mixture. The mixture is then incorporated together for about 30 minutes after which further solvent is added and the mixture is further blended together for several hours.

Hot or cold water is continuously run through the incorporator jacket during mixing to maintain the required dough temperature. After mixing the resulting dough is produced which may be pressed or extruded through a suitable die. The extruded product is cut and dried in an oven at a temperature of about 45^{o}C

Extrusion may be carried out using a rotating twin screw extrusion machine e.g. a rotating twin screw extrusion machine as described in copending UK Patent Application No. 8607170 by the present Applicant Company.

The propellant obtained by extrusion of compositions according to the present invention may be obtained in any suitable form. For example, the propellant may be obtained in the form of sticks or granules of known shape. Sticks are usually formed by cutting to a suitable length rods or strands extruded through suitable dies giving a shape including a longitudinal slot. Granules are usually similarly formed by cutting to much shorter length rods or sticks obtained by extrusion. Normally such granules have small holes, e.g. seven or nineteen holes running lengthwise therethrough to provide suitable burning surfaces.

An important feature of certain propellant products is the web size of the product shape or configuration. This parameter, well known to those skilled in the propellants art, is the minimum thickness of propellant to be burnt through from one surface to another. For example, for a propellant product having simple tube configuration, the web thickness is the outer to inner wall thickness of the cross-sectional annulus of the tube. Web sizes of propellant products incorporating compositions embodying the invention may vary over a range according to the specific application, e.g. from 0.5mm to 4.0mm, although the more desirable web sizes at the lower end of this range, e.g. from 0.5mm to 2.0mm, will generally be suitable for most applications because the compositions generally have a low burning rate.

When a product is required with a web size greater than about 1.5mm the dough is preferably extruded into solid cords which are subsequently pressed together again and reconstituted into a dough. The reformed dough is then extruded again through dies and cut to give the required product shape which is subsequently dried and hardened. This double extrusion technique reduces aeration in the product thus improving its mechanical properties.

Where the product has a web size less than about 1.5mm, the dough may be formed into the product shape in a single extrusion step.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figures 1 and 2 are graphs of shatter resistance (measured at $-40^{o}C$) plotted against propellant web size for propellants embodying the present invention.

Example 1

The following composition, herein referred to as Composition 1, was made into a dough by the method described above:

Composition 1

Nitrocellulose (13.1% N)	21.3% by weight
Nitroglycerine	17.7% by weight
RDX	55% by weight
Dibutyl phthalate	5.0% by weight
Carbamite	1.0% by weight

The resulting dough was extruded into several products having a range of web sizes in both a slotted tube and a 7-hole multitube (i.e. a cylinder having lengthwise holes) configuration. The slotted tubes had a length of about 600mm and an outer diameter of 6.5mm. The 7-hole

multitubes had an outer diameter of about 10mm, a length of about 13mm and a hole diameter of about 1mm. The properties of the products after drying in an oven for several hours were as follows:

Force Constant	1279 kJ/Kg
Flame Temperature	3667 ^{o}K
Calorimetric Value	4805 kJ/Kg
<u>Gaseous Combustion</u>	
Products	% by volume
CO_2	10.31
CO	32.35
H_2O	19.19
H_2	15.01
N_2	23.11

Mean Molecular Weight 23.8

Rate of Burning at 139 MPa (9 tsi) 128 mm/sec

Density 1.670 g/ml

Temperature of Ignition 184 ^{o}C

Storage Life:

Greater than 10 years under normal magazine conditions.

<u>Example 2</u>

The following composition, herein referred to as Composition 2 was made into a dough by the method described above:

Composition 2

Nitrocellulose	(13.1%N)	16.5% by weight
Nitroglycerine		16.5% by weight
RDX		55% by weight
Picrite		2.0% by weight
Dibutyl Phthalate		5.0% by weight
Carbamite		5.0% by weight

The resulting dough was extruded into several products having a range of web sizes in both a slotted tube and a 7-hole multitube (i.e. a cylinder having lengthwise holes) configuration. The slotted tubes had a length of about 600mm and an outer diameter of about 6.0mm. The 7-hole multitube had an outer diameter of 10mm, a length of about 13mm and a hole diameter of about 1mm. The properties of the products after drying in an oven for several hours were as follows.

Force Constant	1210 kJ/kg
Flame Temperature	3239^{o}K
Calorimetric Value	4169 kJ/kg
Density	1.636 g/ml
Rate of Burning	90 mm/sec at 130 MPa

Gaseous Combustion Products	Percentage by volume
CO_2	5.4
CO	37.8
H_2O	15.46
H	19.20
N_2	22.09

Mean Molecular Weight 22.4

Rate of Burning at 139 MPa (9 tsi) 90 mm/sec
Temperature of Ignition 181 ^{o}C

Storage Life: Greater than 10 years under normal magazine conditions.

Example 3

Composition A specified A above was made in the same manner as Composition 1 in Example 1 and formed into a similar multitube product, Product A, under similar process conditions. The properties of Product A with which those of Products 1 and 2 embodying the invention may be compared and contrasted, and are shown in Table 1 as follows.

Table 1: Comparative properties of propellant composition products

Product	Propellant force (KJ/kg)	Shatter resistance number at web size 1.5mm
Product 1	1279	15 (maximum)
Product A (for comparison)	1060	5

In Table 1 the shatter resistance number is the rating assigned to the product after being fired three times successively under conditions simulating gun firing at -40^{o}C. This is obtained by awarding an appropriate rating number to the product after each firing and adding the results to obtain the total rating. The rating numbers for individual firings were assigned according to the following Table 2:

Table 2

State of Product after firing	Rating number
No visible deterioration of surface	5
Surface flaws but no cracks	4
Minor cracks and/or a single deep capillary	2
Split grains, not more than 2 per group of 7 and/or multiple deep capillaries	1
Split grains, more than 2 per group of 7	0

Thus, the shatter resistance number represents a measure of varying graded degrees of shattering based on the number and size of surface flaws, cracks or splits formed in the propellant grains. Thus, the higher the rating number the better the resistance to shattering.

The shatter resistances of Compositions 1 and 2 are, in fact, high over a range of web sizes. Figures 1 and 2 illustrate the variation of shatter resistance with web size for 7-hole multitube and slotted tube products of Composition 1 (Figure 1) and Composition 2 (Figure 2) respectively.

Composition 1 above is preferred for use in applications where the propellant force is desirably maximised whereas Composition 2 is preferred for use in high energy applications where a relatively low flame temperature is required for the energy level involved.

Claims

1. A gun propellant composition comprising the following components in the stated relative proportions by weight, the sum of the relative proportions adding to 100:

Component A:	a mixture of nitrocellulose and nitroglycerine	30 to 40 parts
Component B:	RDX (cyclo-1,3,5-trimethylene --2,4,6-trinitramine)	50 to 60 parts
Component C:	carbamite (diethyldiphenyl urea)	1 to 10 parts

2. A composition as claimed in 1 and wherein the nitrocellulose and nitroglycerine are present in the composition in the relative proportions of A parts by weight of nitrocellulose and B parts by weight of nitroglycerine wherein A is in the inclusive range 40 to 60 and B is the inclusive range 60 to 40.

3. A composition as claimed in claim 1 or claim 2 and wherein the weight percentage content of nitrogen in the nitrocellulose is in the range 12 to 14 per cent.

5. A composition as claimed in any one of the preceding claims and wherein the relative percentage by weight of carbamite present in the composition is in the range 3% to 5%.

6. A composition as claimed in any one of the preceding claims and wherein the composition includes from 3 per cent to 6 per cent by weight of a di-alkyl phthalate non-energetic plasticiser.

7. A composition which is substantially the same as Composition 1 or Composition 2 specified herein.

8. A gun propellant which has been made from a composition as claimed in any one of the preceding claims.

9. A gun propellant as claimed in claim 8 and which has been extruded by a twin rotating screw extrusion machine.

PATENTS ACT 1977
EXAMINER'S REPORT TO THE COMPTROLLER
UNDER SECTION 17(5)
(The Search Report)

12

Application No. 8722362

FIELD OF SEARCH: The search has been conducted through the relevant published UK patent specifications and applications, and applicati ns published under the Eur pean Patent Convention and the Patent Co-operation Treaty (and such other documents as may be mentioned below) in the following subject-matter areas:-

UK Classification C1D

(Collections other than UK, EP & PCT:) Selected US specifications in IPC sub class C06B

DOCUMENTS IDENTIFIED BY THE EXAMINER (NB In accordance with Section 17(5), the list of documents below may include only those considered by the examiner to be the most relevant of those lying within the field (and extent) of search)

Category	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

CATEGORY OF CITED DOCUMENTS

X relevant if taken alone
Y relevant if combined with an ther cited document
P document published on or after the declared priority date but before the filing date f the present application
E patent document published on r after, but with priority date earlier than, the filing date of the present application

Search examiner
R A H CASLING

Date of search
21 April 1988

SF 2